/BMC HYDRO GW STUDY ADDENDUM

Hydro Engineering

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FAX TRANSMISSION COVER SHEET

Date: *November 21, 1994*

To: *Dale Shay - Brohm Mining Company*

Fax: *(605) 578-1709*

Re: *Addendum A - Ground-Water Quality Changes*

Sender: *George Hoffman*

YOU SHOULD RECEIVE 23 PAGE(S), INCLUDING THIS COVER SHEET. IF YOU DO NOT RECEIVE ALL THE PAGES, PLEASE CALL (307) 266-6597.

ADDENDUM A

GROUND-WATER QUALITY CHANGES

ADDENDUM A

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A.0 INTRODUCTION

Water quality data was updated through August 1994 in the database and plots of selected constituents and wells were developed to aid in this evaluation of the ground-water quality changes at the Gilt Edge site. Mining at the Gilt Edge site started in 1988. The water table in the Dakota Maid pit was penetrated in mid 1992. Therefore, the main ground-water changes would not be expected until after mid 1992. The placement of Gilt Edge overburden material in piles would have the potential to affect some ground-water wells mid 1992 and after the start of mining in 1988.

A.1 GROUND-WATER QUALITY

An updated Figure 6-2 presents the total dissolved solids plots for upstream bedrock wells in Strawberry Creek. This plot shows that the TDS in wells GW4, GW5 and GW6 have been fairly steady with a possible small decline in average TDS concentration in bedrock well GW4 and a possible small increase in average TDS concentration in bedrock wells GW5 and GW6. The small increase in concentration in wells GW5 and GW6 are well within the range of natural changes in TDS of this water. The 1994 data for these three wells does not show any significant change in recent time. [The small average change in concentrations prior to and after 1991 in wells GW5 and GW6 could possibly be due to the Gilt Edge operation.] significance of change?

The TDS plot for alluvial wells GW3, GW7, BES11 and BES17 were updated in Figure 6-3. This plot shows that the TDS in well GW3 has stayed at similar values in 1994 to those observed for the last several years. A significant increase in TDS was observed in alluvial well GW3 after the start of the Gilt Edge Mine in 1988. This increase is likely due to the backfill of overburden material upstream of well GW3 in Strawberry Creek. Well GW7 is downstream of well GW3 in the Strawberry Creek alluvium. [Water quality changes since the start of mining at Gilt Edge have varied by a similar amount as those observed prior to mining.] [A small increase in the average concentration may exist since the penetration of the ground-water table in 1992 in the Dakota Maid pit.] The most recent TDS measurement in August, 1994 in well GW7 of 2,267 mg/l is a significant increase over the average value in the last several years. Additional monitoring with time is needed to determine if this value is representative of a significant increasing trend or a function of some short-term effect. The removal of the relic tailings in Strawberry Creek upstream of GW7 may be the cause of the increase of TDS in the alluvial aquifer in this area. If the removing of the relic tailings is the cause, concentrations would be expected to decrease in the near future. A small amount of average increase in TDS in the alluvial aquifer at GW7 may be due to the Gilt Edge operation. Figure 6-3 also presents the TDS concentration plots for alluvial wells BES11 and BES17. These two alluvial wells are further downstream in the Strawberry alluvial system. Neither one of these plots show any effects from the Gilt Edge operation on the TDS concentration in the Strawberry alluvial system at these two locations.

Figure 6-4 was updated to present the TDS concentration plots for wells BED18, GW8, GW10 and GW12. The TDS plot for bedrock well BED18 shows a gradual decrease in concentration from 1988 through 1994. This gradual decrease in concentration could be a natural trend or may be caused by the placement of overburden material in the waste depository south of this well. TDS concentrations in bedrock well GW10, which is located in the middle of the waste depository, shows a slight decline in TDS concentrations in 1993 and 1994. Bedrock well GW9, which is located further down Ruby Gulch and is not shown on the plot, also shows a gradual decline in TDS concentrations. It is possible that the waste depository affected the recharge of water to the bedrock aquifer in this area in a manner which decreased the concentrations of TDS. Figure 6-4 also presents the TDS for Ruby Gulch alluvial wells GW8 and GW12. The TDS concentration of these two alluvial wells varies with time as expected for a shallow ground-water system but no consistent change with time is being observed.

The TDS concentrations for wells BED4, BED11, BED15 and BES15 are presented in Figure 6-5. Bedrock well BED4 is outside of the mine area and shows a fairly steady TDS concentration with time. Concentrations in bedrock well BED11, which is south of the Sunday Pit adjacent to Strawberry Creek, has shown lower concentrations in 1993 and 1994 than prior to these dates. Water quality concentrations in bedrock well BED15 have shown an overall gradual decline with time. Trends in this well should not be given any significance because this well contains cement contamination which is likely to affect major constituent concentrations. Figure 6-5 also presents the TDS concentration plot for Ruby Gulch alluvial well BES15. This plot shows a gradual increase in TDS from 1991 through 1993. The two values in 1994 are similar to those prior to the Gilt Edge Mine. This plot indicates that the alluvial ground-water in Ruby Gulch at this location was possibly affected by the Gilt Edge operation. wetland ??

Figure 6-11 presents the sulfate concentrations for bedrock wells GW4, GW5 and GW6. The sulfate concentrations in well GW4 have gradually declined since the start of operation at the Gilt Edge Mine. This trend is similar to the TDS changes in well GW4 and may be due to a change in recharge effects on the bedrock aquifer in this area. This figure also presents plots of bedrock wells GW5 and GW6 which both show a gradual increase in sulfate concentrations since the start of the Gilt Edge operation. These trends are similar to those observed for TDS. [The Gilt Edge mining may have caused the small increase in sulfate concentrations in these two wells since 1991.]

The sulfate concentrations in alluvial wells GW3, GW7, BES11 and BES17 are presented in an updated Figure 6-12. This plot shows that the sulfate concentrations have significantly increased in the alluvial aquifer at well GW3 since the start of the Gilt Edge operation. A small average increase in sulfate concentration may have occurred since the start of the Gilt Edge operation in alluvial well GW7, which is further downstream from GW3. The majority of the sulfate concentration in the alluvial aquifer at GW7 existed in the aquifer prior to mining and therefore, a large portion of the elevated sulfate at this location are due to effects prior to the Gilt Edge operation. A slight overall increase in the sulfate concentrations seems to have occurred in the alluvial well BES11. This increase is well within natural changes in the alluvial aquifer in this area but may be due to the Gilt Edge operation. The sulfate concentrations in alluvial well BES17 have been steady and show no significant effect from the Gilt Edge operation. Sulfate concentrations in bedrock wells GW10 and BED18 and alluvial well GW12 in the Ruby Gulch area have been low and steady. The 1994 data in alluvial well GW8 shows an increasing trend in sulfate concentrations in this area. Additional data with time is needed to determine if a significant trend is developing in the alluvial aquifer at well GW8.

Wetland ??

An updated Figure 6-14 presents the sulfate concentrations for bedrock wells BED4, BED11 and BED15 and alluvial well BES15. The average recent sulfate concentration in each of these three bedrock wells is similar to those values observed prior to the Gilt Edge operation. The sulfate concentrations gradually increase since 1991 in the alluvial aquifer in Ruby Gulch at BES15. This increase in sulfate concentrations is likely due to the waste depository being placed in Ruby Gulch. A recent decline in sulfate concentrations has been observed in 1994 with values approaching those prior to the Gilt Edge operation.

The pH values for bedrock wells GW4, GW5 and GW6 are presented in an updated Figure 6-20. This plot shows that the pH values for these three bedrock wells has been fairly stable since the start of the Gilt Edge operation. A small decline may have occurred in the average pH in bedrock well GW5 but this change is well within natural variation.

An updated Figure 6-21 presents the pH values for wells GW3, GW7, BES11 and BES17. A gradual declining trend in pH is likely due to the backfill of overburden upstream of well GW3 in the Strawberry Creek drainage during the Gilt Edge operation. The pH values in alluvial well GW7 were low prior to the Gilt Edge operation and have been very similar since the operation. The pH of the two Strawberry Creek alluvial wells further downstream have been steady and similar to those observed prior to the Gilt Edge operation.

Figure 6-22 presents the pH concentrations for bedrock wells BED18 and GW10 and Ruby Gulch alluvial wells GW8 and GW12. The pH values in these four wells are still similar to those values observed prior to the start of the Gilt Edge operation.

Figure 6-23 presents a plot of the pH values versus time for wells BED4, BED11, BED15 and BES15. This plot shows that the pH has been close to neutral and fairly steady for wells BED4, BED11 and BES15. A gradual overall decline in the pH is occurring in well BED15. This well contains cement contamination and, therefore, the pH should not be used from this data. Well BED15 needs to be acidified to remove the effects of the cement contamination.

A.2 WATER QUALITY CHANGES , PREMINE TO 1992

In summary, the water quality changes that have been observed since the start of the Gilt Edge Mine have shown an increase in concentrations in wells GW5 and GW6 since the start of the operation of the Gilt Edge Mine. A larger increase in sulfate and TDS has been observed in alluvial well GW3 and is likely due to the effect of the placement of overburden in upper Strawberry Creek. A small average increase in well GW7 has been observed for both TDS and sulfate and could be due to the mining of the Dakota Maid and Sunday pits. This data indicates that the ground water in upper Strawberry Creek contained a significant amount of high concentrations prior to the Gilt Edge mining. An increase in TDS and sulfate concentrations has occurred in the Strawberry alluvial system at well GW3 since the start of the Gilt Edge operation in 1988. The small increase in TDS and sulfate concentrations in bedrock wells GW5 and GW6 seems to have started prior to the penetration of the ground-water in 1992 in these pits and, therefore, may be more a function of the overburden fills than the connection developed with the Dakota Maid and Sunday pits.

The waste depository in Ruby Gulch seems to have caused a decline in TDS and sulfate concentrations in the bedrock aquifer at wells BED18 and GW10. This decline may be due to natural changes in ground-water quality. An increase in TDS and sulfate in alluvial well BES15 at the downstream end of Ruby Gulch has occurred since the placement of the overburden in this drainage. The alluvial wells GW8 and GW9, which are upgradient of BES15 and close to the waste depository, do not show any effects on the ground-water quality from this operation. An increase in sulfate concentration in 1994 in Ruby well GW8 could be a start of an increasing trend that is caused by the Ruby waste depository. The increases that were observed in BES15 are probably due to surface water transporting higher concentrations of TDS and sulfate to this area of the Ruby Gulch alluvium. A decrease in 1994 in sulfate and TDS concentrations indicates that this effect has been greatly decreased.

A.3 WATER QUALITY CHANGES, 1992 TO PRESENT

A small average increase in concentrations in alluvial well GW7 seems to have occurred since the penetration of the ground-water in the Dakota Maid and Sunday pits in 1992. This increase could be caused by changes in water quality in the pre-Gilt Edge mining, natural variations or could be the result of the Dakota Maid and Sunday mining. The Strawberry alluvial water quality downstream of GW7 does not show any affects from the Gilt Edge operation except a possible small recent increase in sulfate at well BES11.

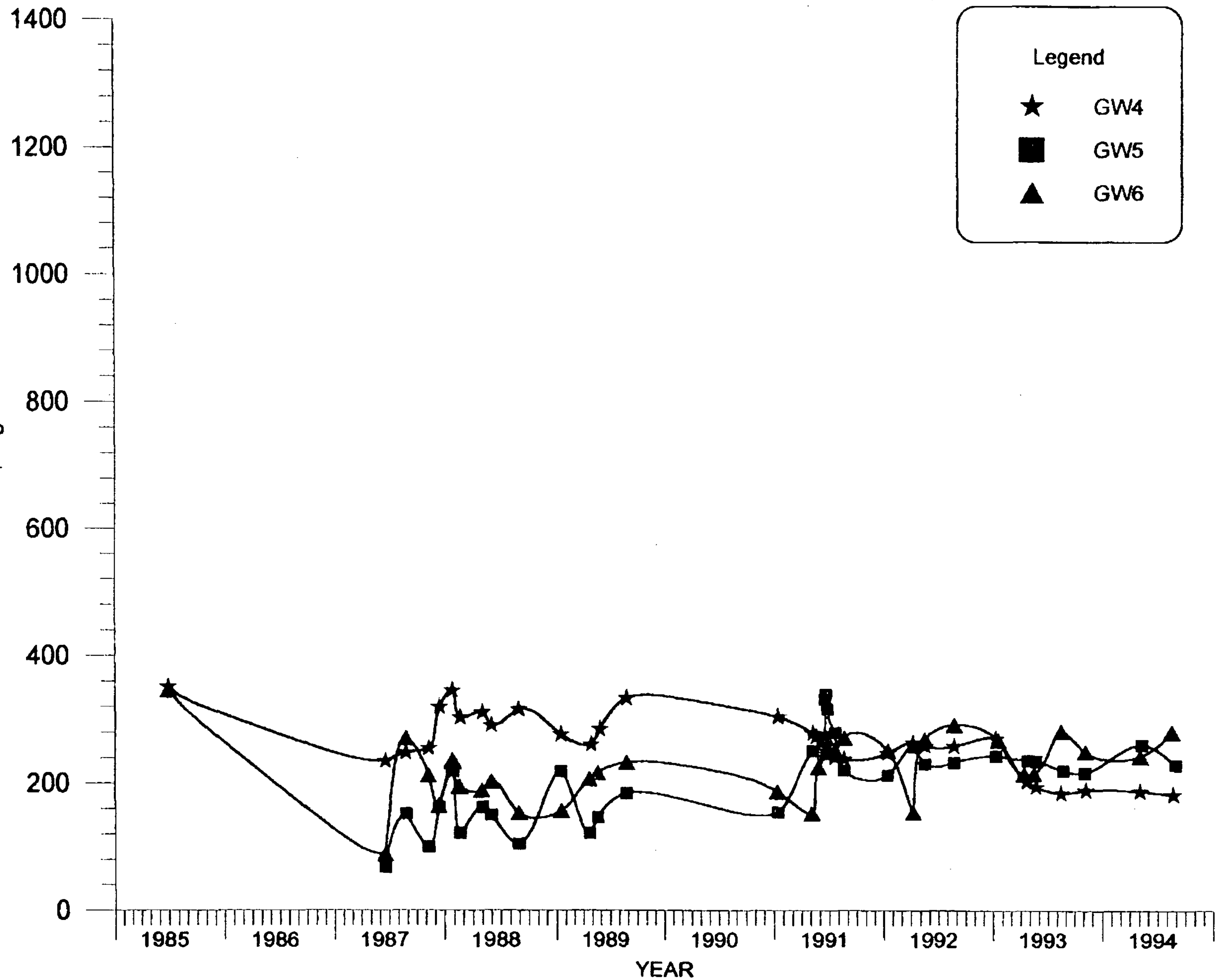

FIGURE 6-2. TDS IN WELLS GW4, GW5 AND GW6.

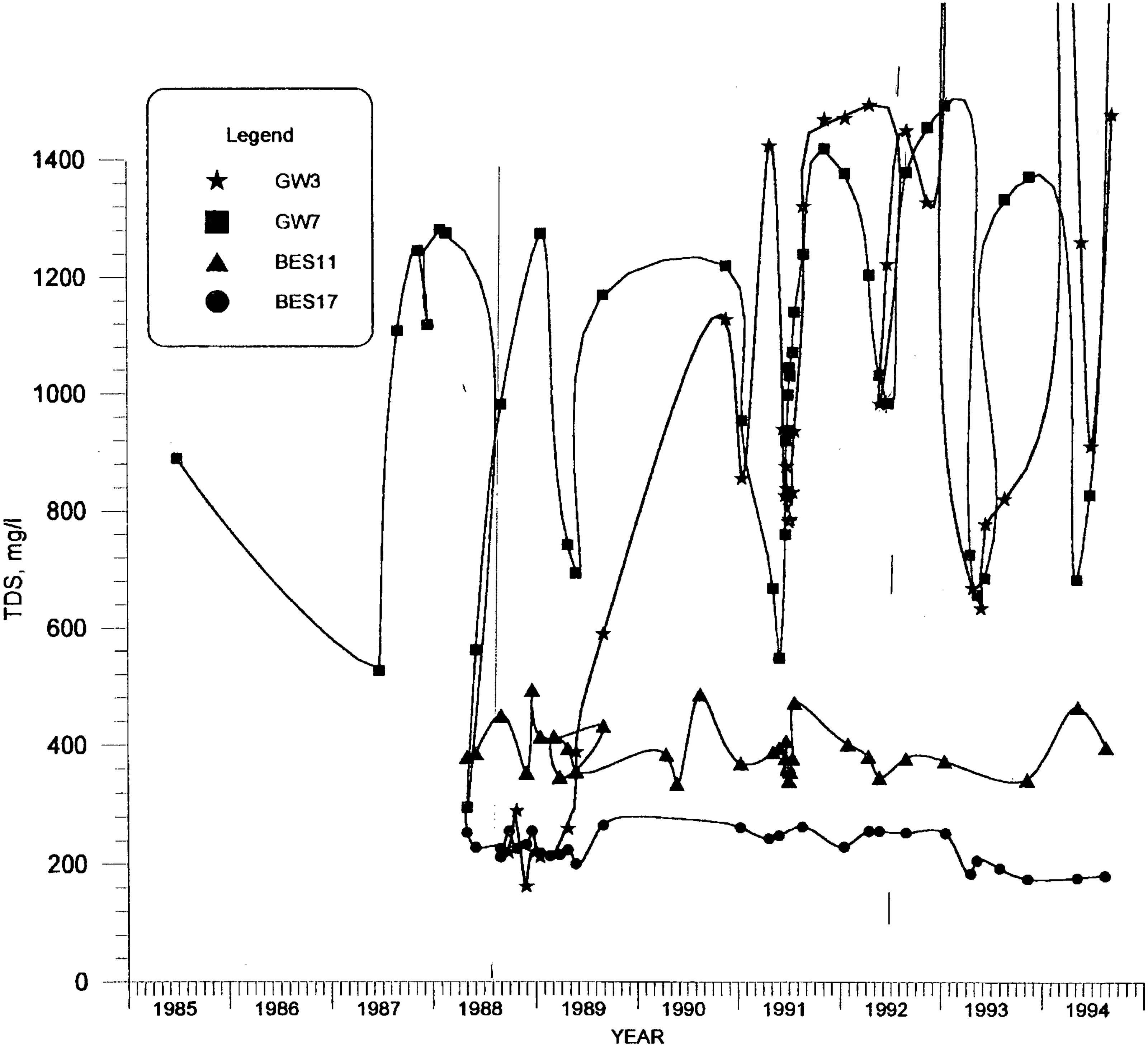

FIGURE 6-3. TDS IN WELLS GW3, GW7, BES11 AND BES 17.

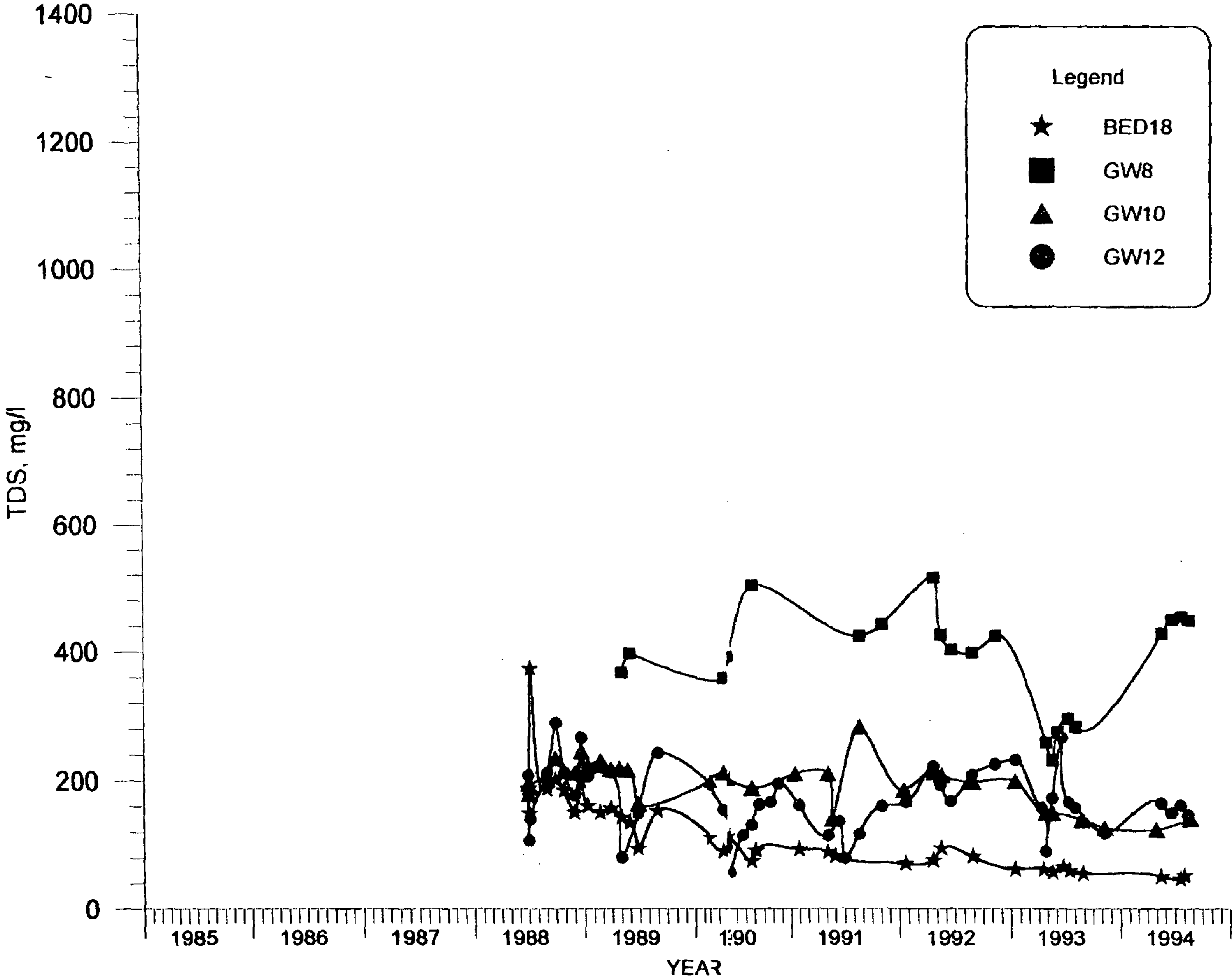

FIGURE 6-4. TDS IN WELLS BED18, GW8, GW10 AND GW12.

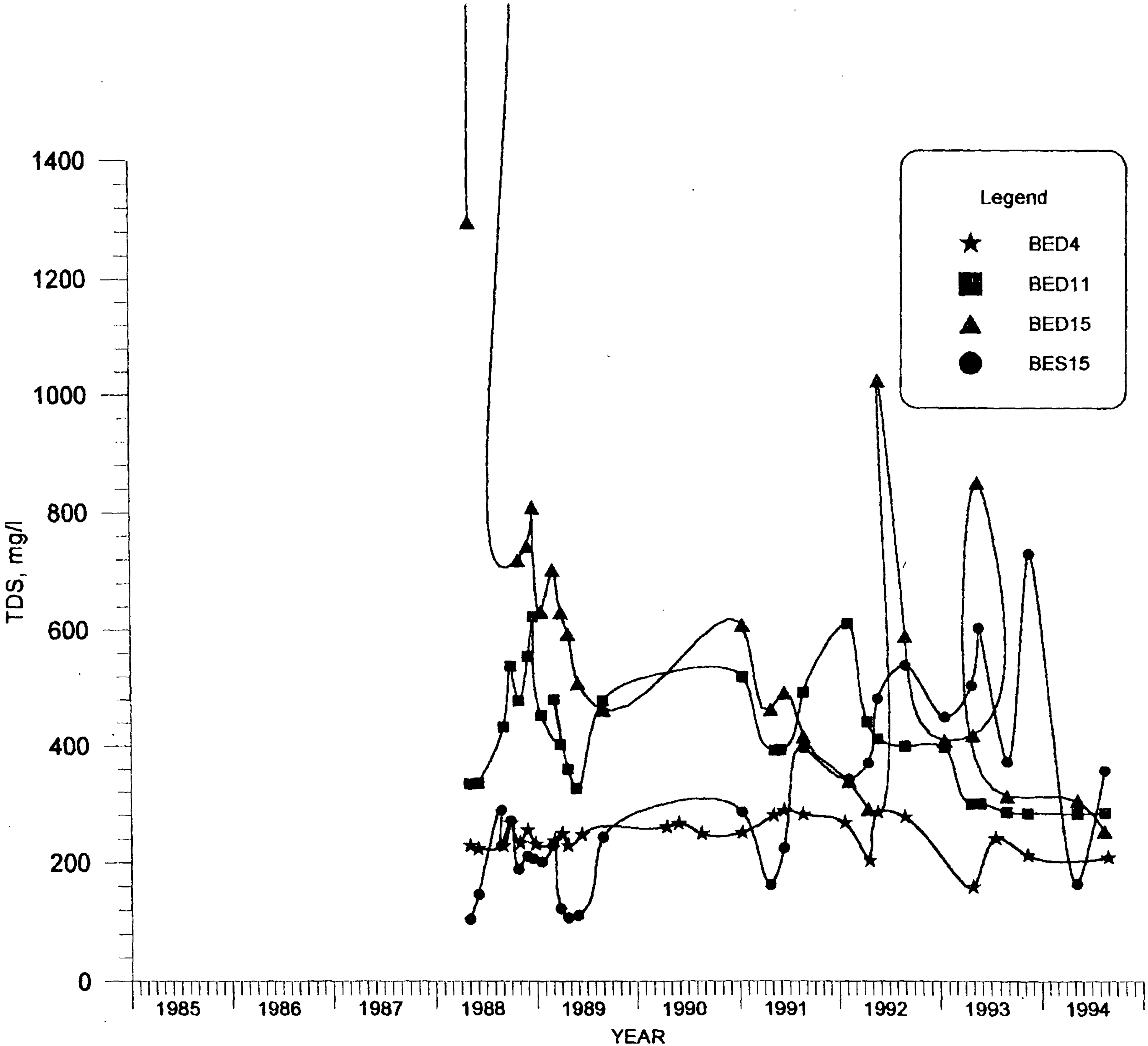

FIGURE 6-5. TDS IN WELLS BED4, BED11, BED15 AND BES15.

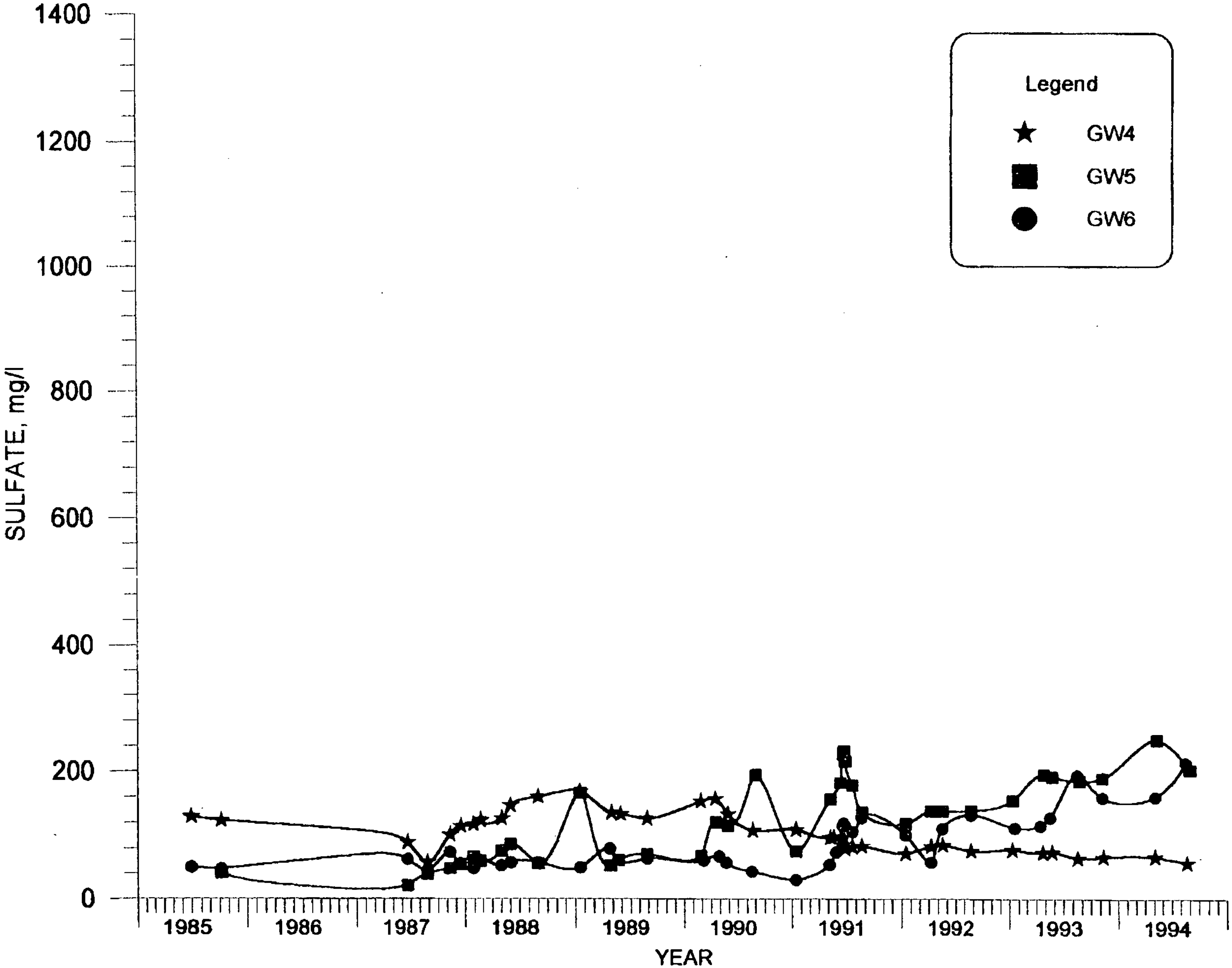

FIGURE 6-11. SULFATE FOR WELLS GW4, GW5 AND GW6.

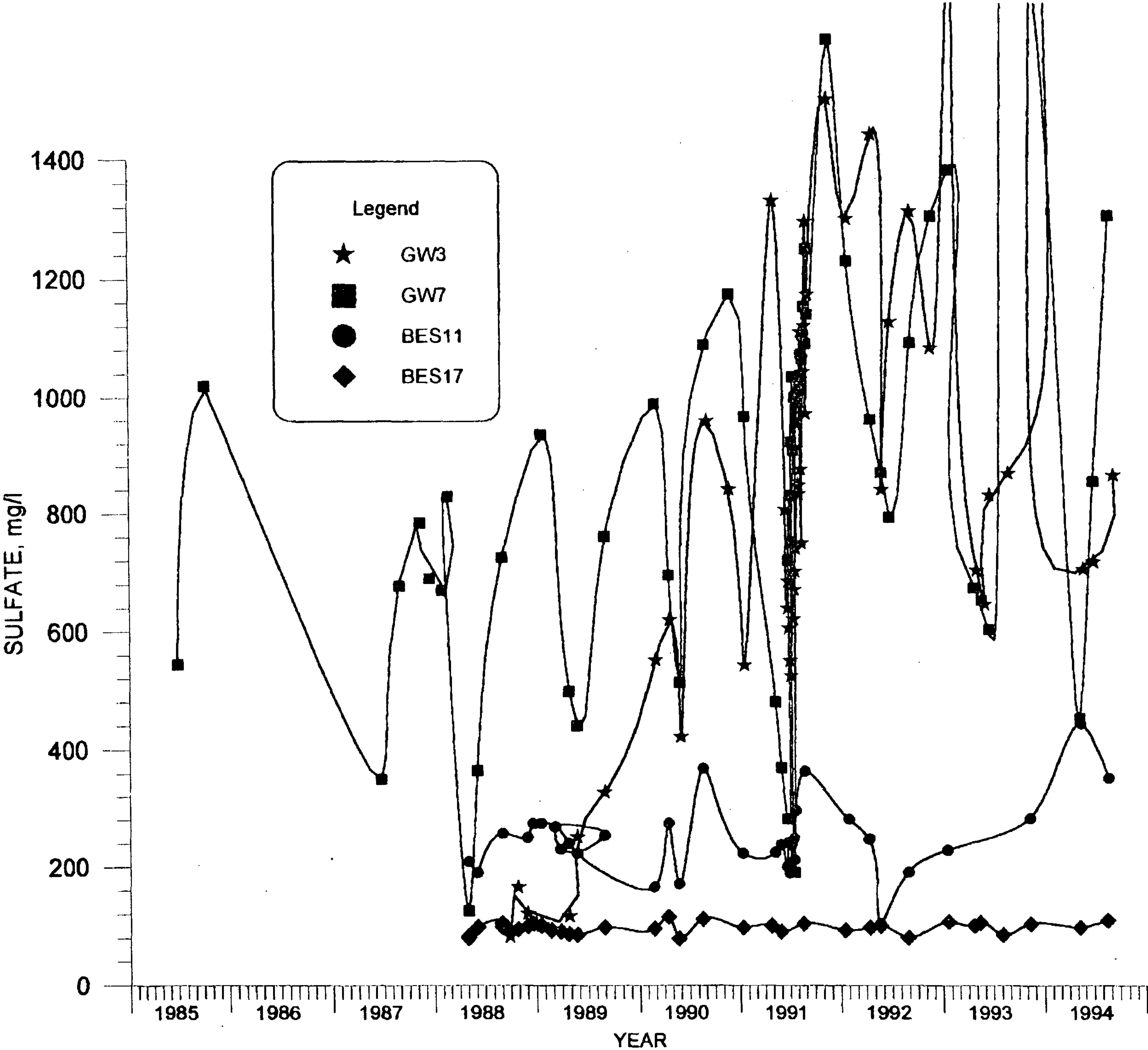

FIGURE 6-12. SULFATE FOR WELLS GW3, GW7, BES11 AND BES17.

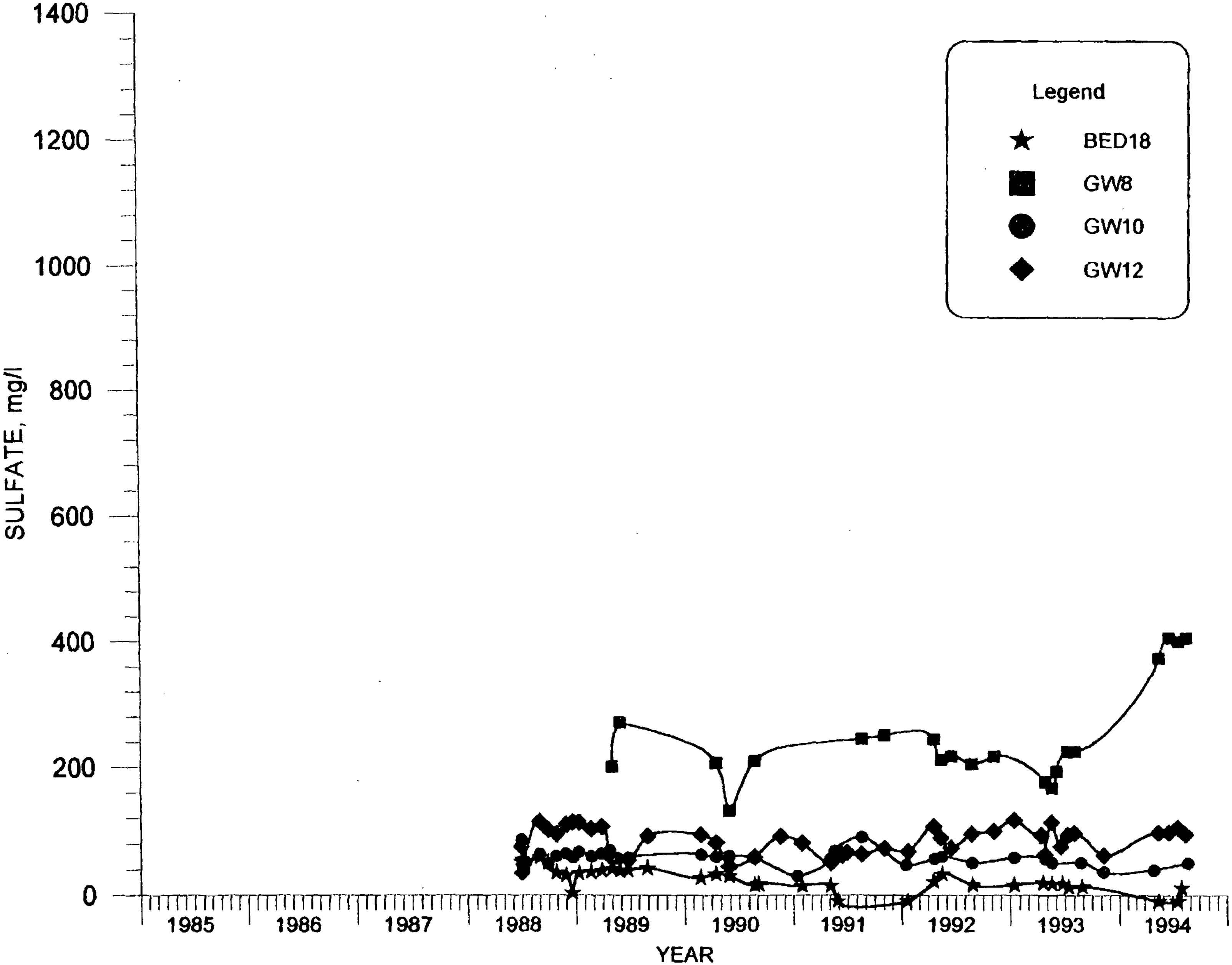

FIGURE 6-13. SULFATE FOR WELLS BED18, GW8, GW10 AND GW12.

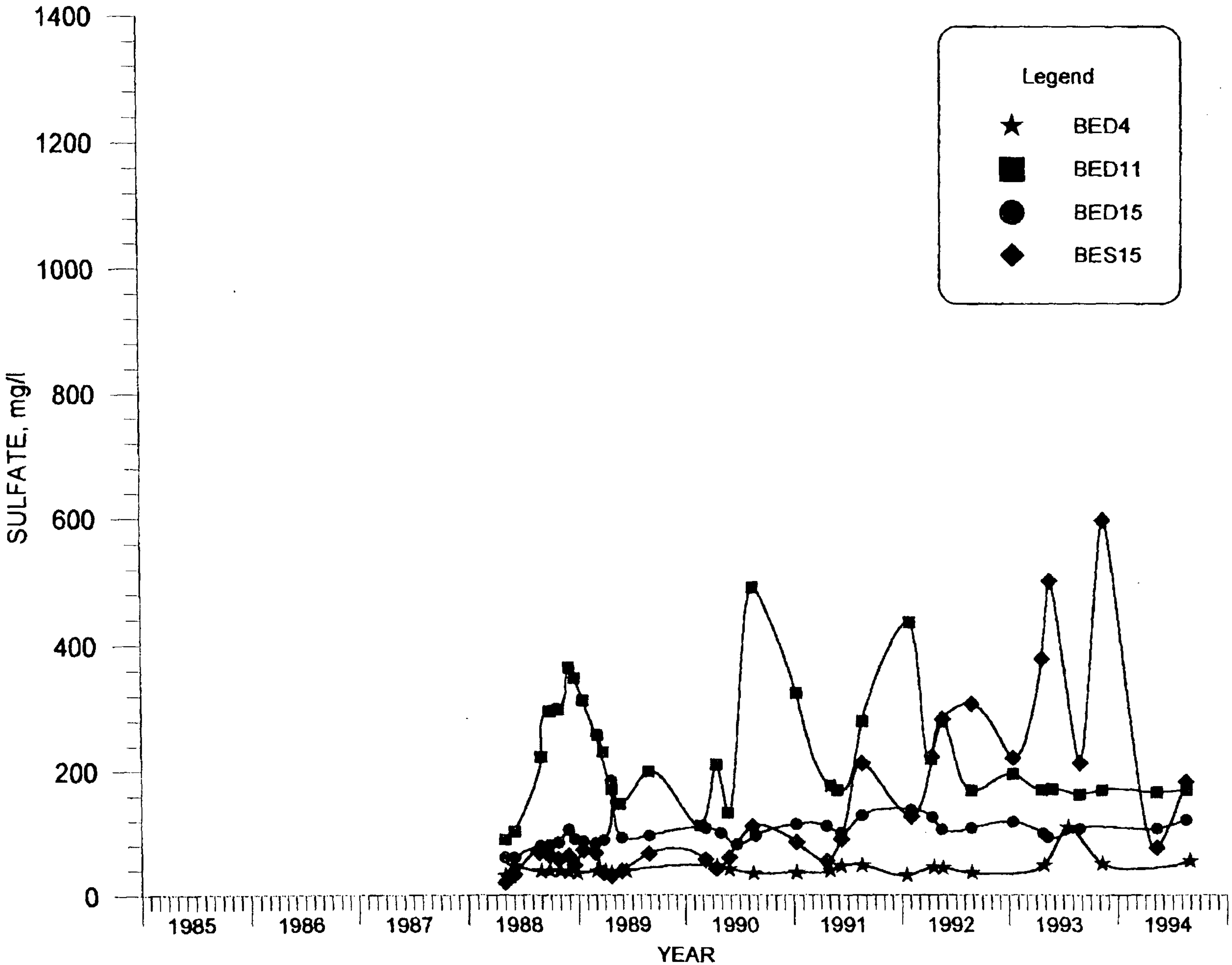

FIGURE 6-14. SULFATE FOR WELLS BED4, BED11, BED15 AND BES15.

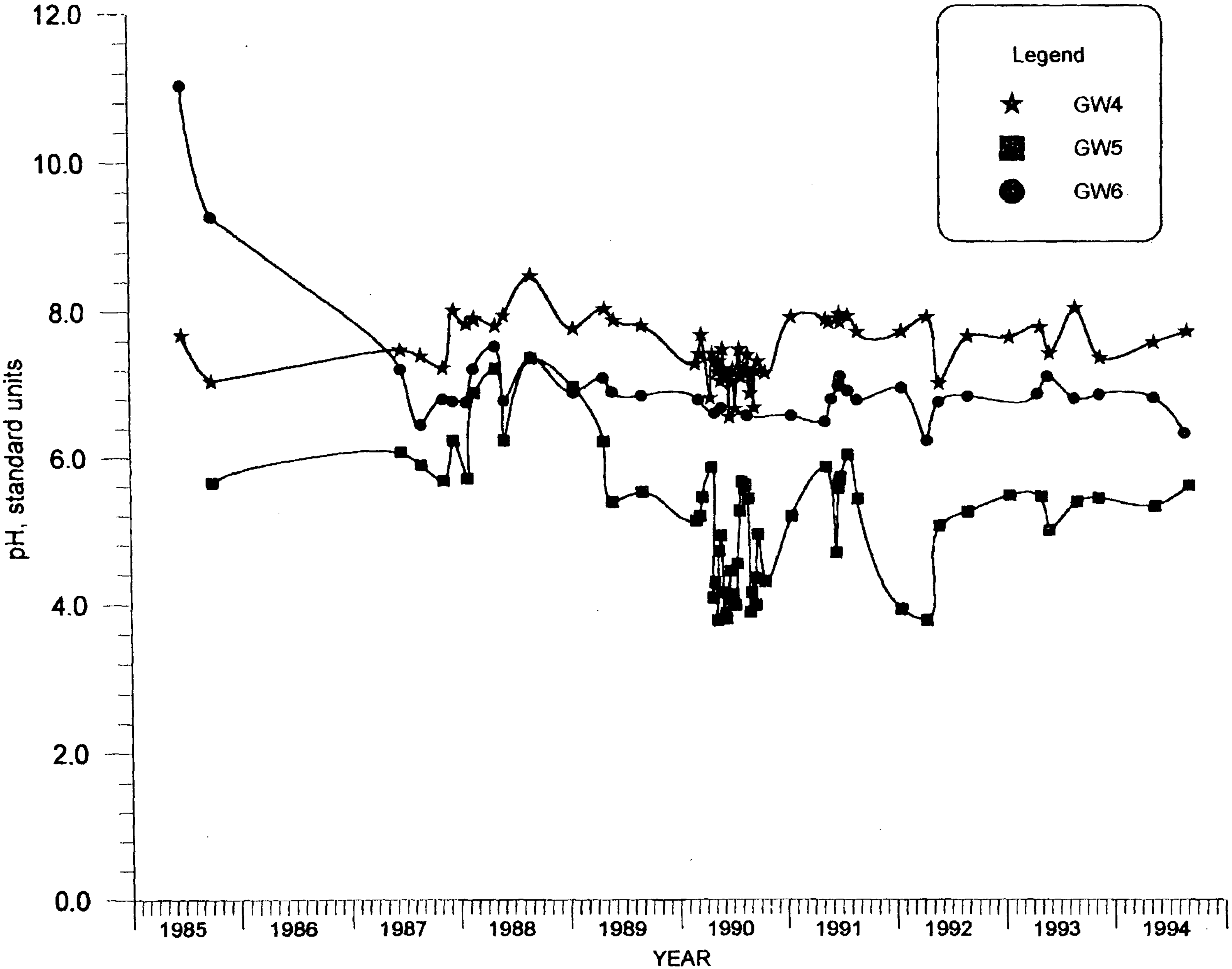

FIGURE 6-20. pH FOR WELLS GW4, GW5 AND GW6.

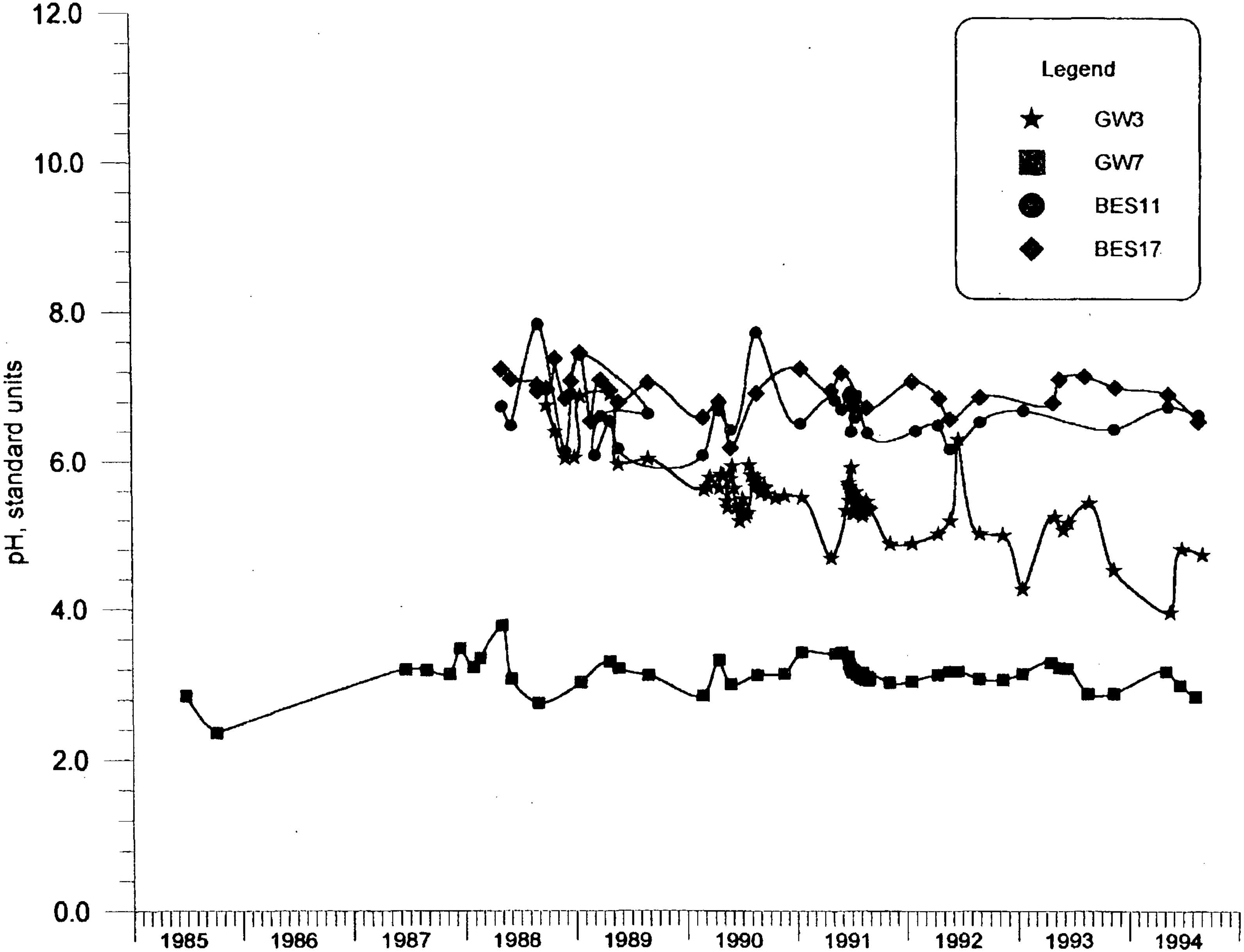

FIGURE 6-21. pH FOR WELLS GW3, GW7, BES11 AND BES17.

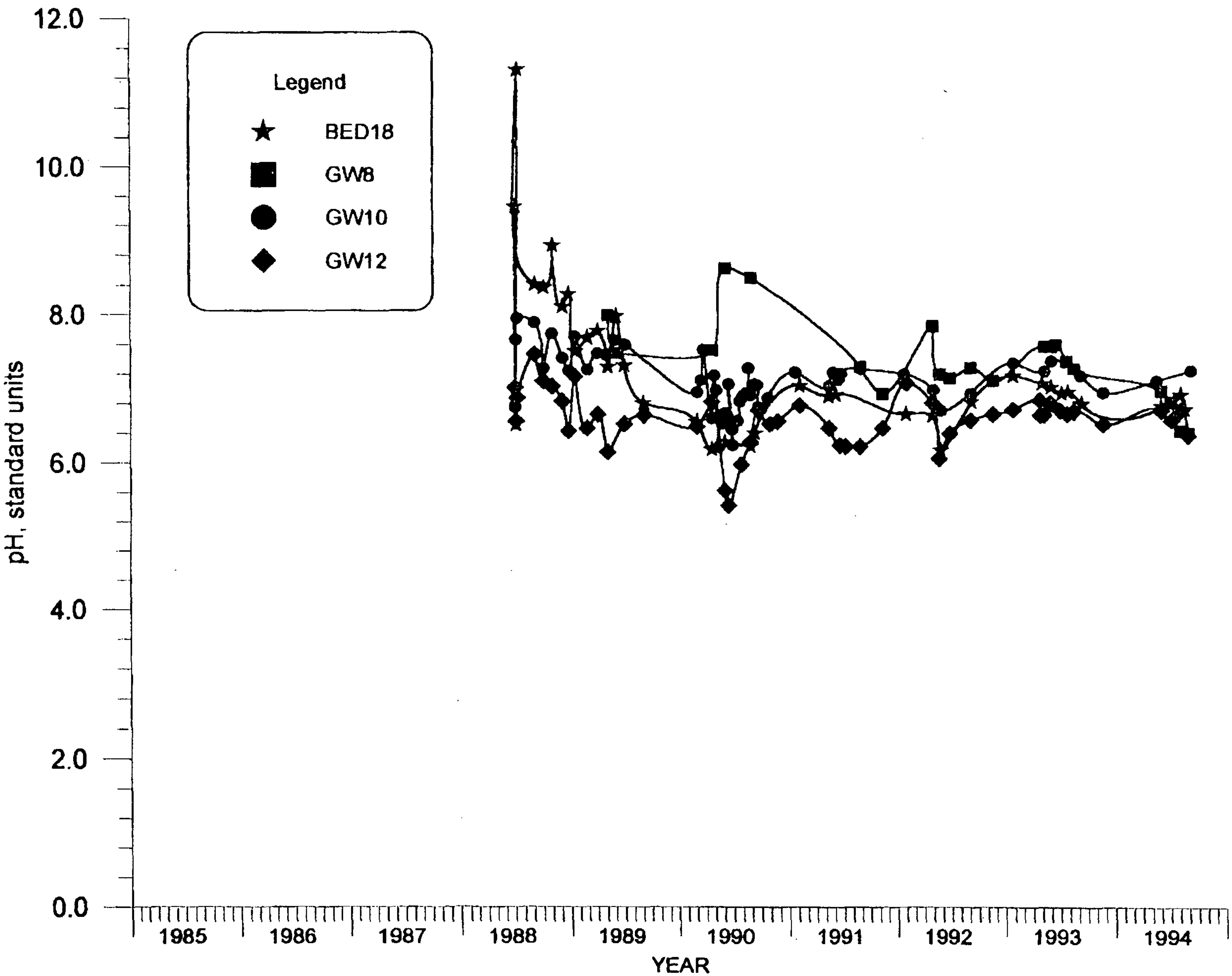

FIGURE 6-22. pH FOR WELLS BED18, GW8, GW10 AND GW12.

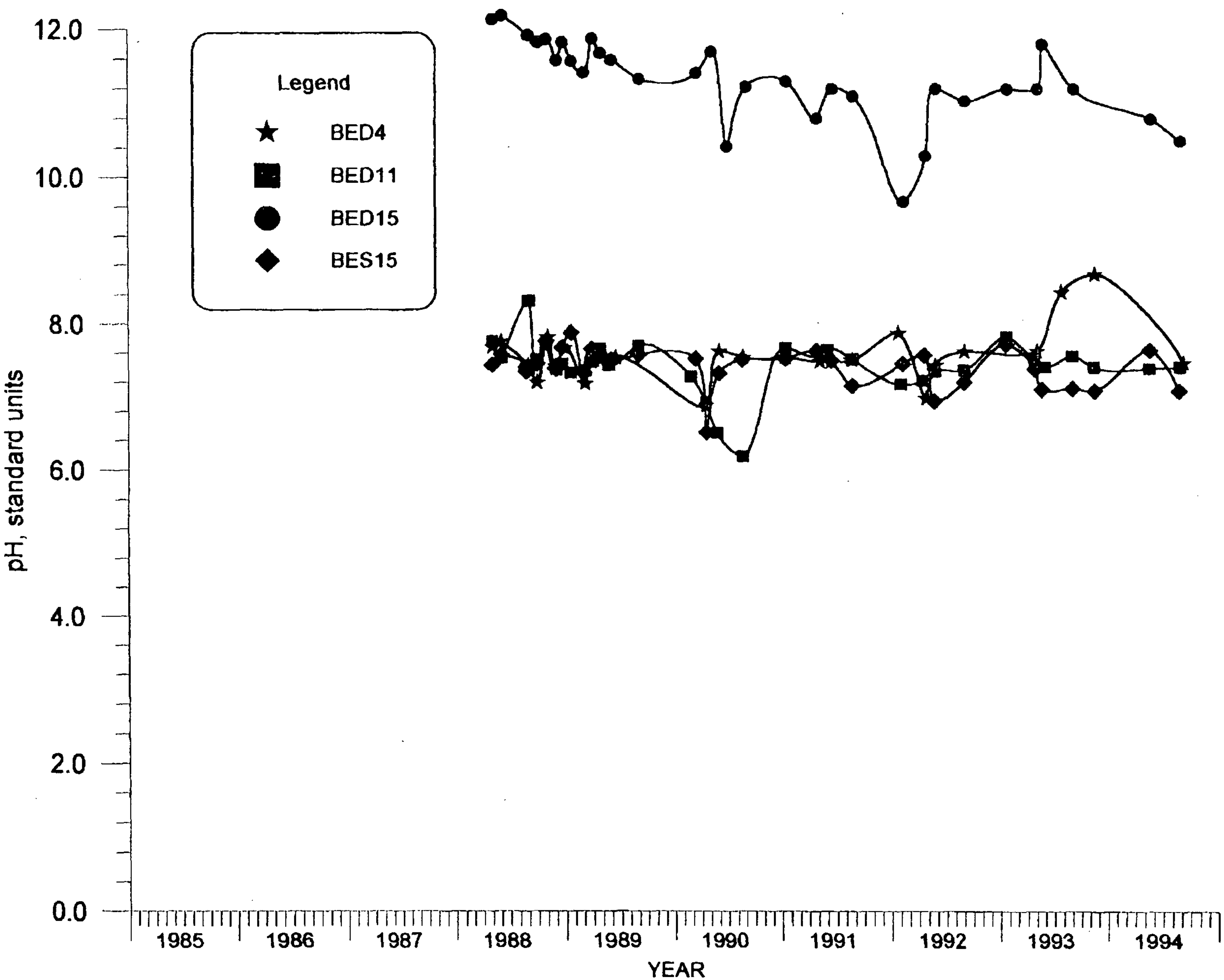

FIGURE 6-23. pH FOR WELLS BED4, BED11, BED15 AND BES15.

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upgradient of pits but not plant fill

The TDS plot for alluvial wells GW3, GW7, BES11 and BES17 were updated in Figure 6-3. This plot shows that the TDS in well GW3 has stayed at similar values in 1994 to those observed for the last several years. A significant increase in TDS was observed in alluvial well GW3 after the start of the Gilt Edge Mine. This increase is likely due to the backfill of overburden material upstream of well GW3 in Strawberry Creek. Well GW7 is downstream of well GW3 in the Strawberry Creek alluvium. Water quality changes since the start of mining at Gilt Edge have varied by a similar amount as those observed prior to mining. A small increase in the average concentration may exist since the penetration of the ground-water table in 1992 in the Dakota Maid pit. The most recent TDS measurement in August, 1994 in well GW7 of 2,267 mg/l is a significant increase over the average value in the last several years. Additional monitoring with time is needed to determine if this value is representative of a significant

Reflection of Relic tailings removal?

increasing trend or a function of some short-term effect. The removal of the relic tailings in Strawberry Creek upstream of GW7 may be the cause of the increase of TDS in the alluvial aquifer in this area. If the removing of the relic tailings is the cause, concentrations would be expected to decrease in the near future. A small amount of average increase in TDS in the alluvial aquifer at GW7 may be due to the Gilt Edge operation. Figure 6-3 also presents the TDS concentration plots for alluvial wells BES11 and BES17. These two alluvial wells are further downstream in the Strawberry alluvial system. Neither one of these plots show any effects from the Gilt Edge operation on the TDS concentration in the Strawberry alluvial system at these two locations.

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lots of rain in 1991 ??

Figure 6-11 presents the sulfate concentrations for bedrock wells GW4, GW5 and GW6. The sulfate concentrations in well GW4 have gradually declined since the start of operation at the Gilt Edge Mine. This trend is similar to the TDS changes in well GW4 and may be due to a change in recharge effects on the bedrock aquifer in this area. This figure also presents plots of bedrock wells GW5 and GW6 which both show a gradual increase in sulfate concentrations since the start of the Gilt Edge operation. These trends are similar to those observed for TDS. The Gilt Edge mining may have caused the small increase in sulfate concentrations in these two wells since 1991.

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An updated Figure 6-14 presents the sulfate concentrations for bedrock wells BED4, BED11 and BED15 and alluvial well BES15. The average recent sulfate concentration in each of these three bedrock wells is similar to those values observed prior to the Gilt Edge operation. The sulfate concentrations gradually increase since 1991 in the alluvial aquifer in Ruby Gulch at BES15. This increase in sulfate concentrations is likely due to the waste depository being placed in Ruby Gulch. A recent decline in sulfate concentrations has been observed in 1994 with values approaching those prior to the Gilt Edge operation.

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Figure 6-22 presents the pH concentrations for bedrock wells BED18 and GW10 and Ruby Gulch alluvial wells GW8 and GW12. The pH values in these four wells are still similar to those values observed prior to the start of the Gilt Edge operation.

Figure 6-23 presents a plot of the pH values versus time for wells BED4, BED11, BED15 and BES15. This plot shows that the pH has been close to neutral and fairly steady for wells BED4, BED11 and BES15. A gradual overall decline in the pH is occurring in well BED15. This well contains cement contamination and, therefore, the pH should not be used from this data. Well BED15 needs to be acidified to remove the effects of the cement contamination.

A.2 WATER QUALITY CHANGES , PREMINE TO 1992

In summary, the water quality changes that have been observed since the start of the Gilt Edge Mine have shown an increase in concentrations in wells GW5 and GW6 since the start of the operation of the Gilt Edge Mine. A larger increase in sulfate and TDS has been observed in alluvial well GW3 and is likely due to the effect of the placement of overburden in upper Strawberry Creek. A small average increase in well GW7 has been observed for both TDS and sulfate and could be due to the mining of the Dakota Maid and Sunday pits. This data indicates that the ground water in upper Strawberry Creek contained a significant amount of high concentrations prior to the Gilt Edge mining. An increase in TDS and sulfate concentrations has occurred in the Strawberry alluvial system at well GW3 since the start of the Gilt Edge operation in 1988. The small increase in TDS and sulfate concentrations in bedrock wells GW5 and GW6 seems to have started prior to the penetration of the ground-water in 1992 in these pits and, therefore, may be more a function of the overburden fills than the connection developed with the Dakota Maid and Sunday pits.

The waste depository in Ruby Gulch seems to have caused a decline in TDS and sulfate concentrations in the bedrock aquifer at wells BED18 and GW10. This decline may be due to natural changes in ground-water quality. An increase in TDS and sulfate in alluvial well BES15 at the downstream end of Ruby Gulch has occurred since the placement of the overburden in this drainage. The alluvial wells GW8 and GW9, which are upgradient of BES15 and close to the waste depository, do not show any effects on the ground-water quality from this operation. An increase in sulfate concentration in 1994 in Ruby well GW8 could be a start of an increasing trend that is caused by the Ruby waste depository. The increases that were observed in BES15 are probably due to surface water transporting higher concentrations of TDS and sulfate to this area of the Ruby Gulch alluvium. A decrease in 1994 in sulfate and TDS concentrations indicates that this effect has been greatly decreased.

This data could indicate that the increase in concentrations in BES15 are from causes other than the Ruby dump

A.3 WATER QUALITY CHANGES, 1992 TO PRESENT

A small average increase in concentrations in alluvial well GW7 seems to have occurred since the penetration of the ground-water in the Dakota Maid and Sunday pits in 1992. This increase could be caused by changes in water quality in the pre-Gilt Edge mining, natural variations or could be the result of the Dakota Maid and Sunday mining. The Strawberry alluvial water quality downstream of GW7 does not show any affects from the Gilt Edge operation except a possible small recent increase in sulfate at well BES11.

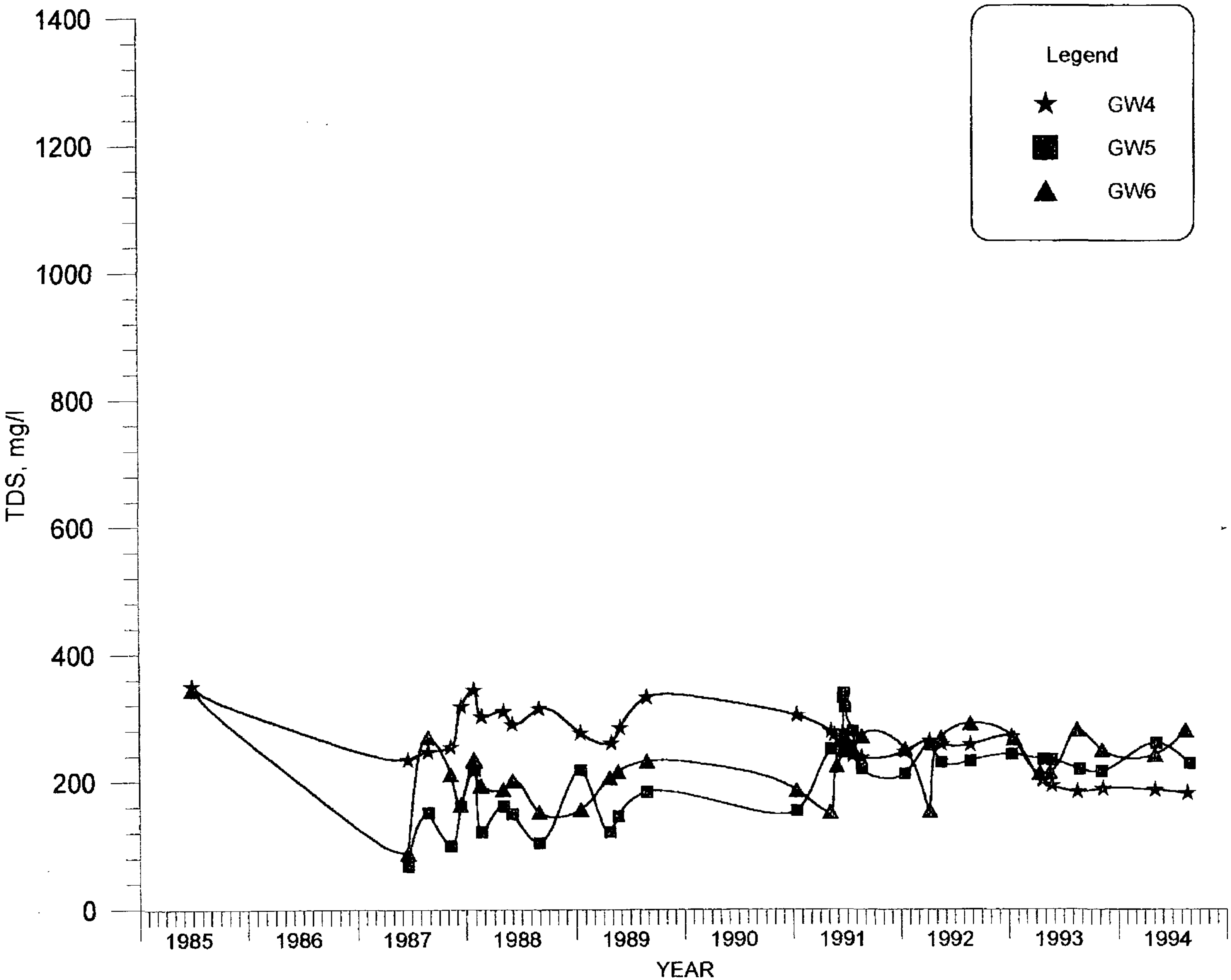

FIGURE 6-2. TDS IN WELLS GW4, GW5 AND GW6.

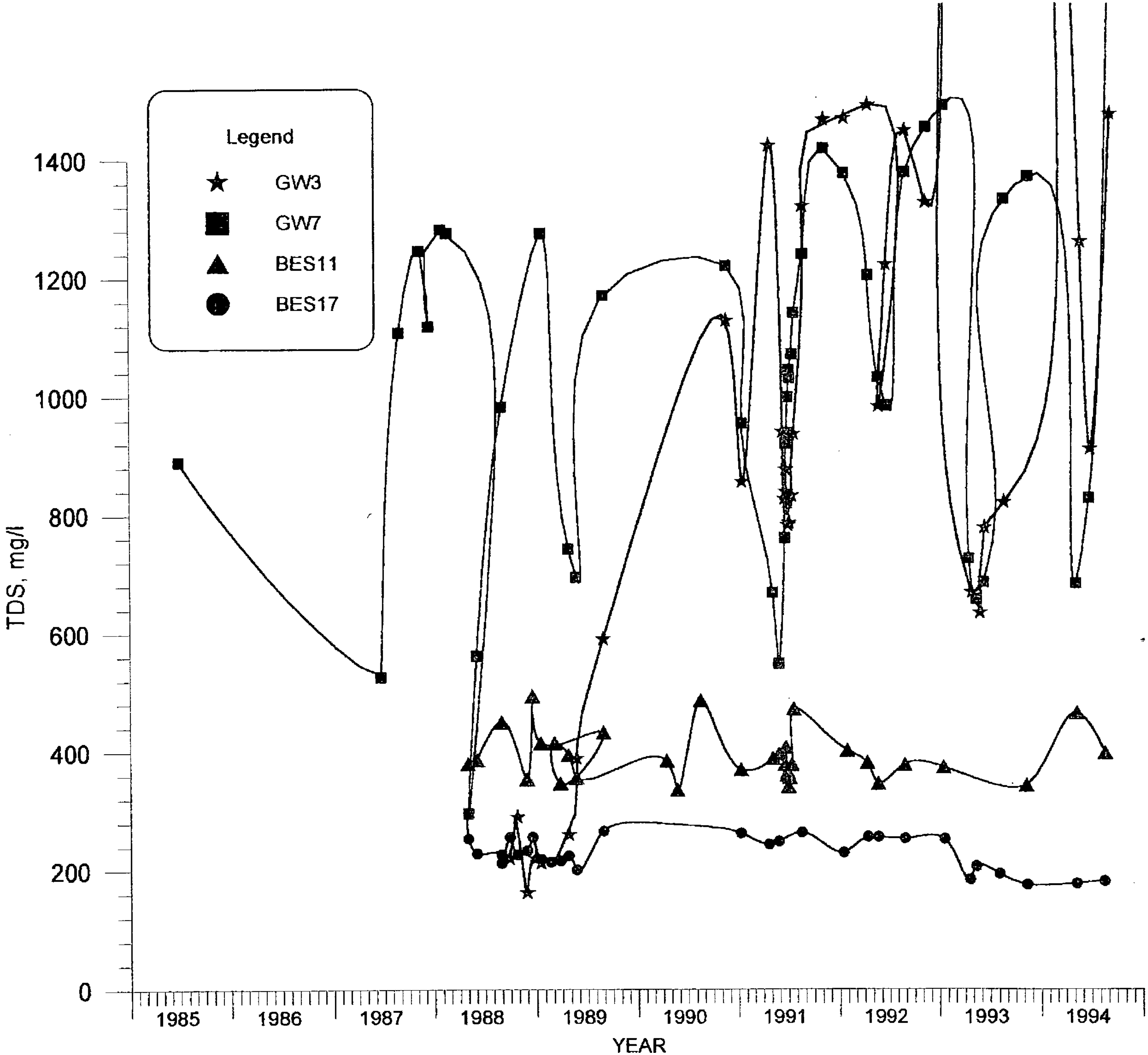

FIGURE 6-3. TDS IN WELLS GW3, GW7, BES11 AND BES 17.

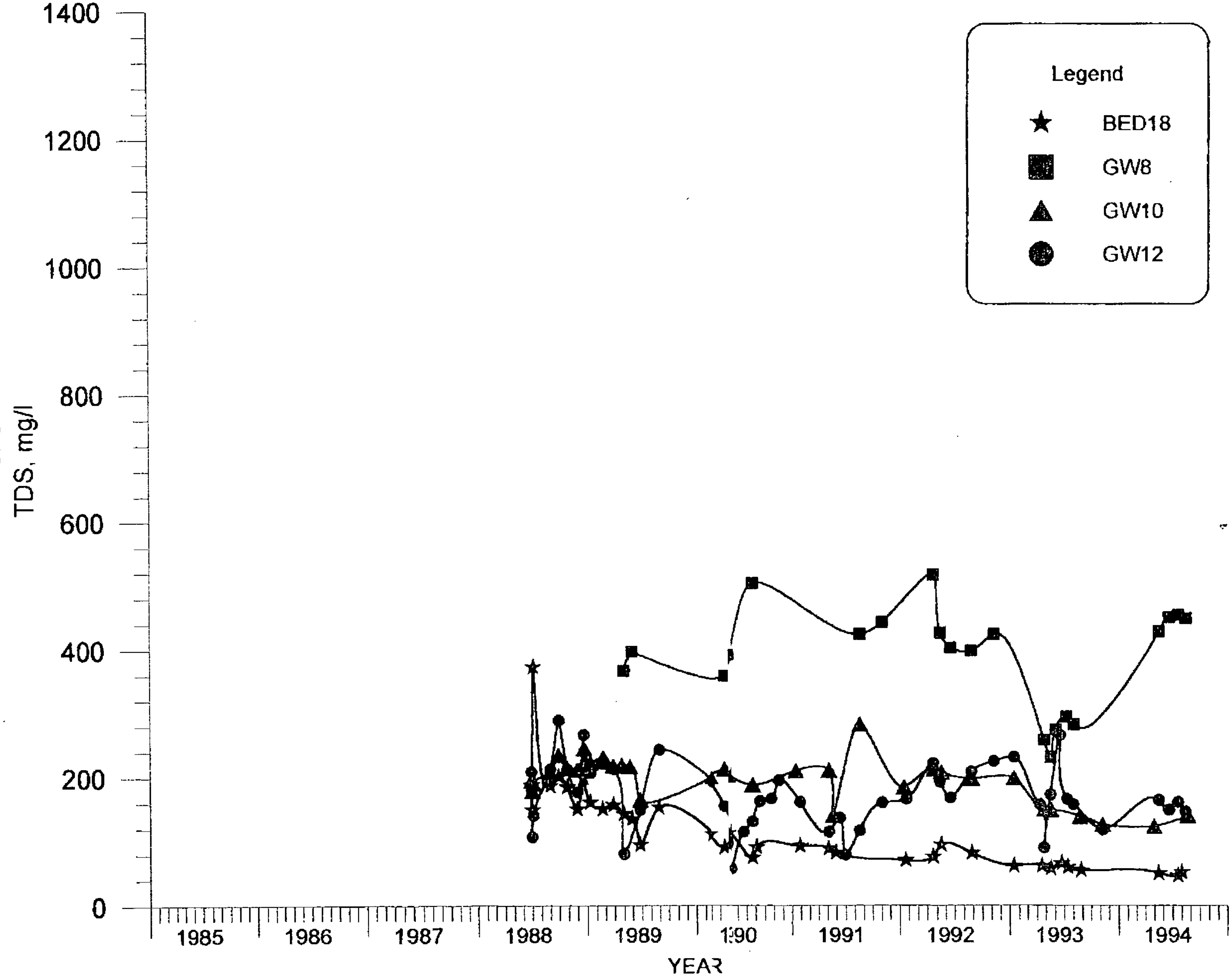

FIGURE 6-4. TDS IN WELLS BED18, GW8, GW10 AND GW12.

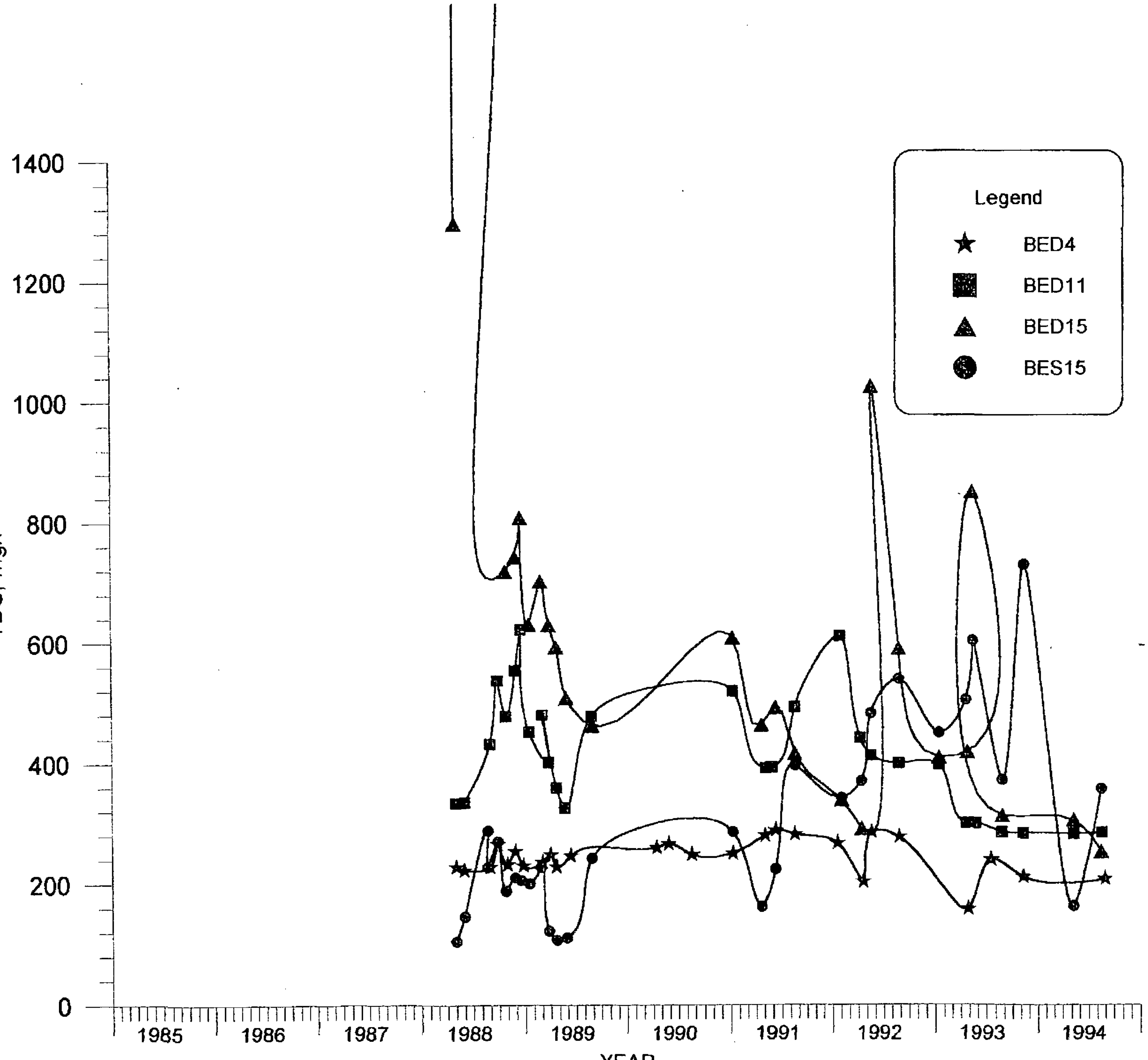

FIGURE 6-5. TDS IN WELLS BED4, BED11, BED15 AND BES15.

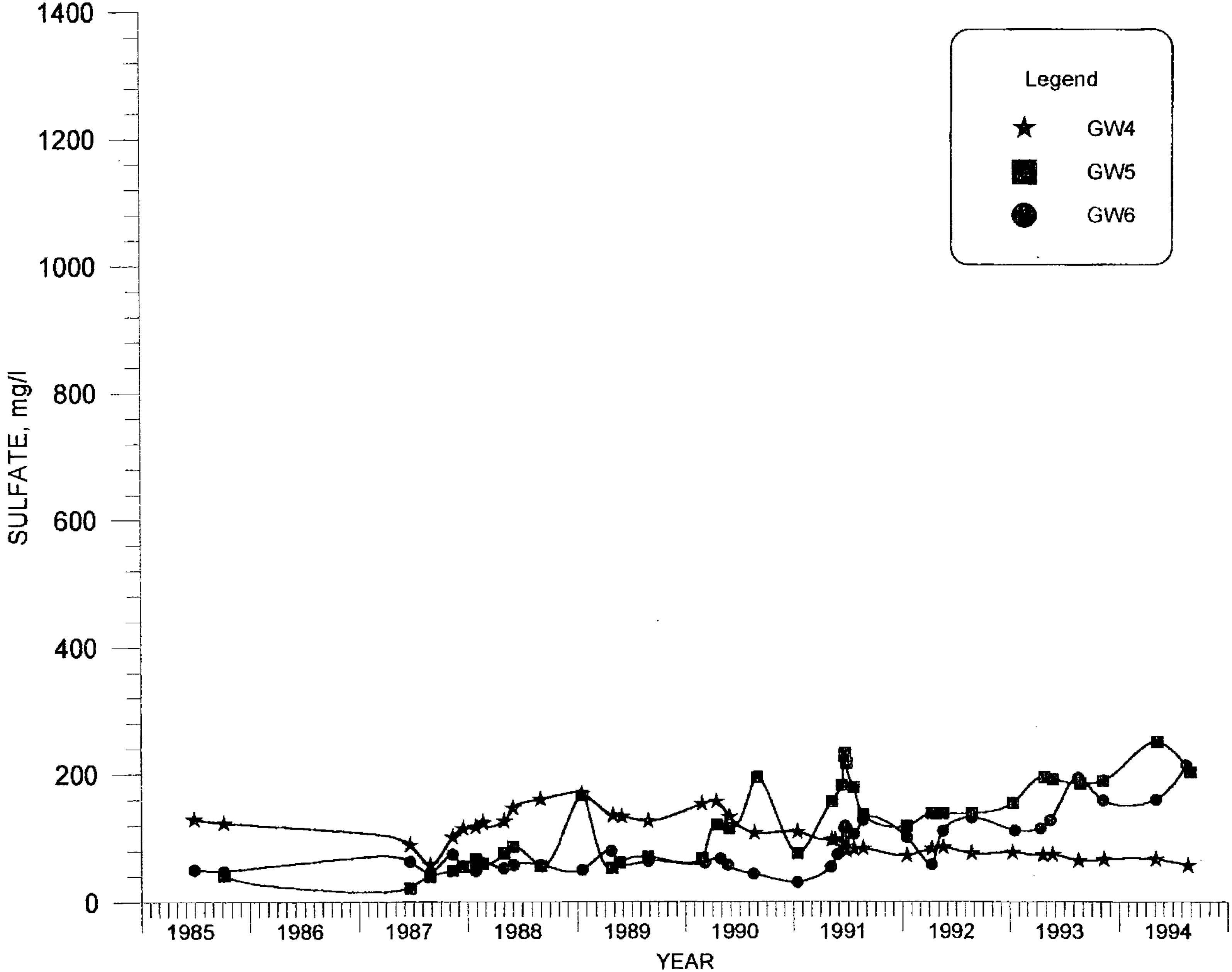

FIGURE 6-11. SULFATE FOR WELLS GW4, GW5 AND GW6.

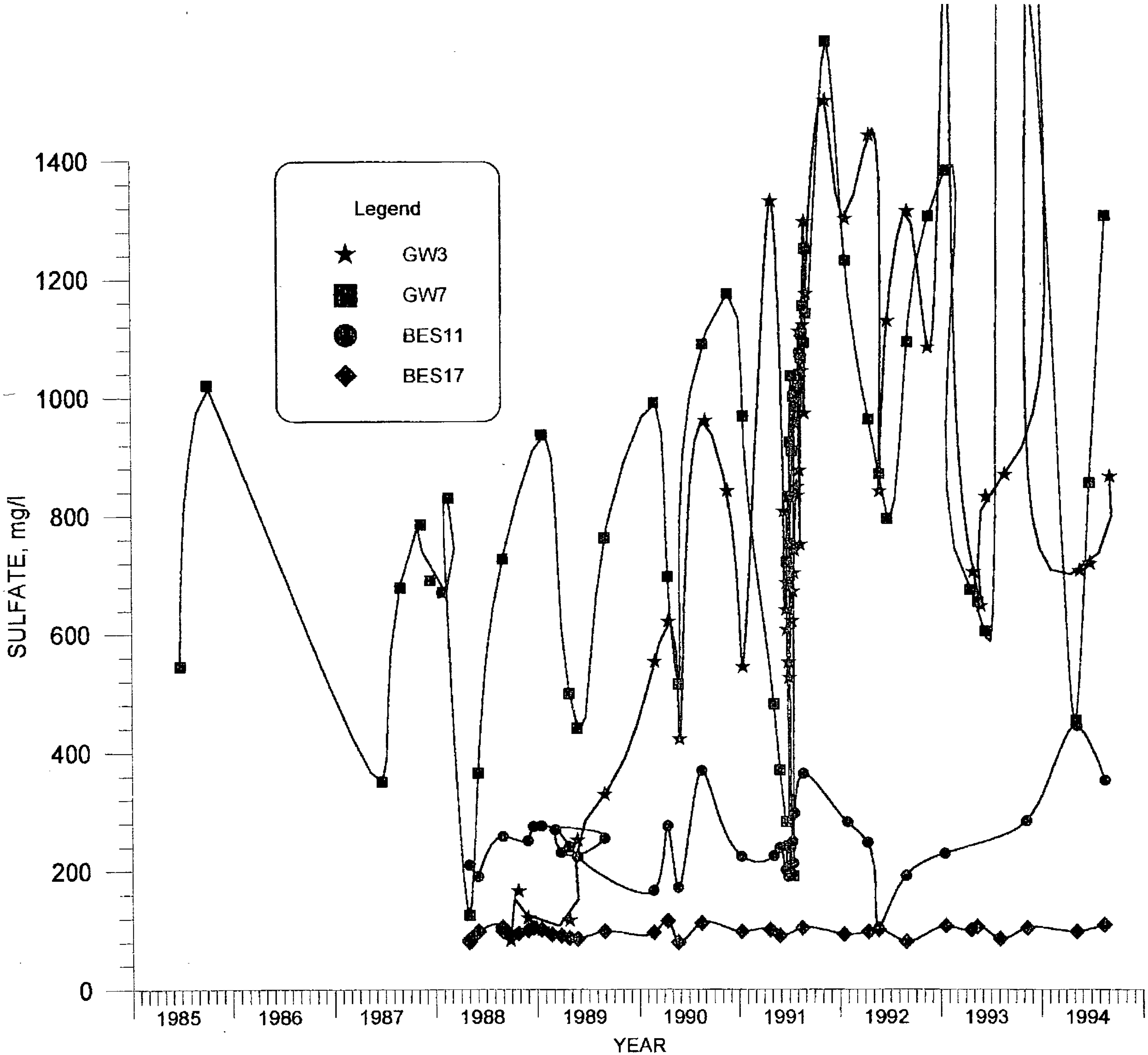

FIGURE 6-12. SULFATE FOR WELLS GW3, GW7, BES11 AND BES17.

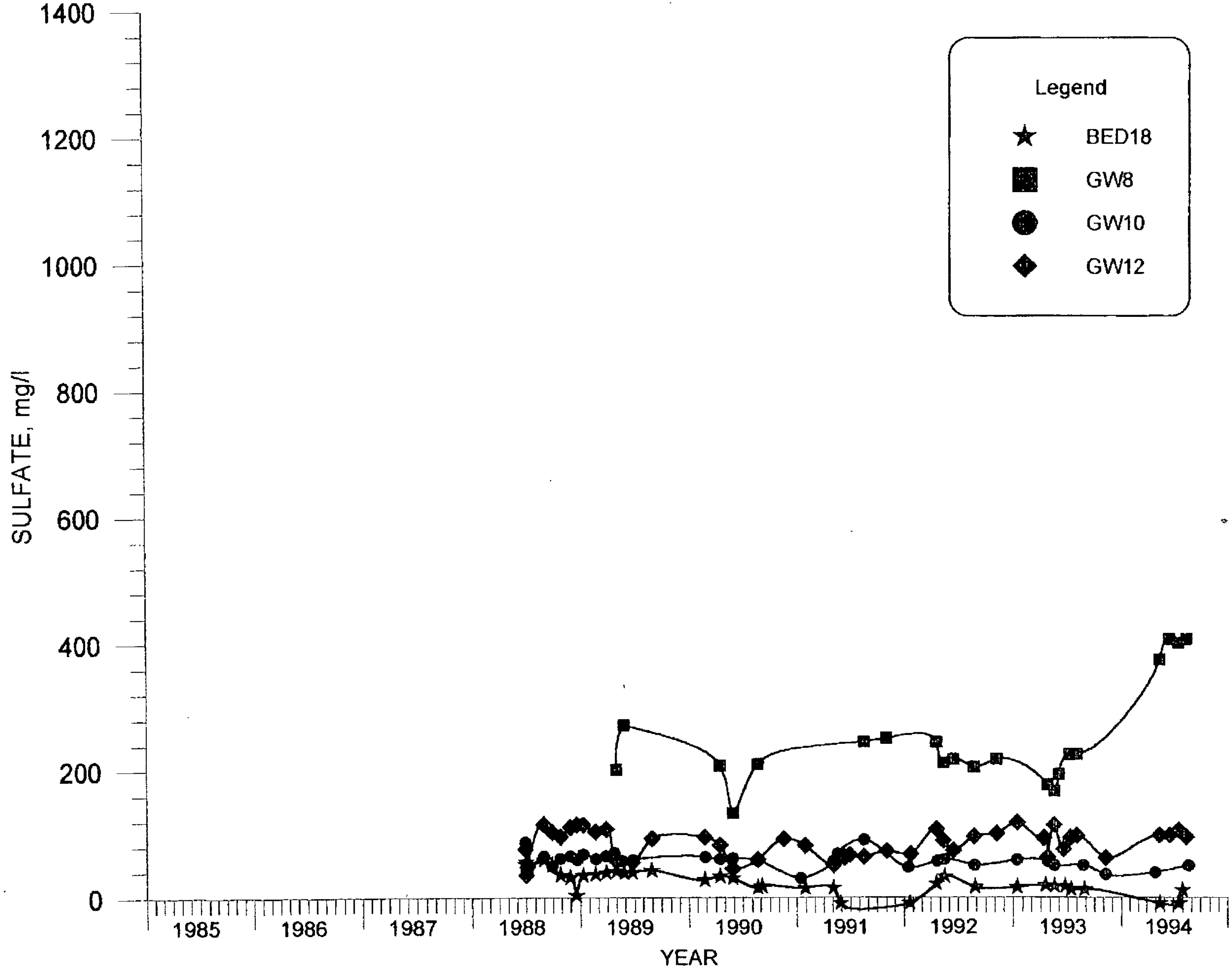

FIGURE 6-13. SULFATE FOR WELLS BED18, GW8, GW10 AND GW12.

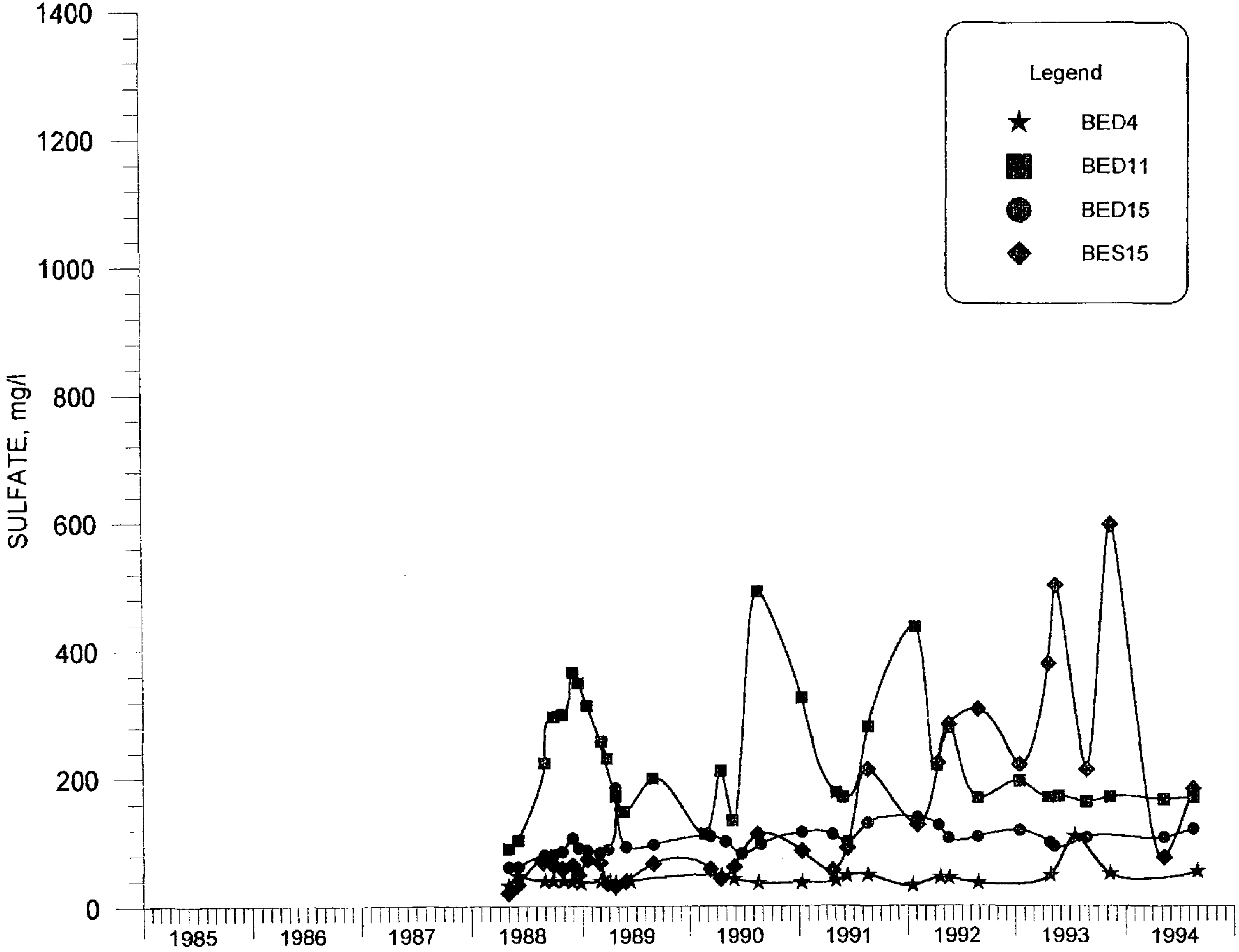

FIGURE 6-14. SULFATE FOR WELLS BED4, BED11, BED15 AND BES15.

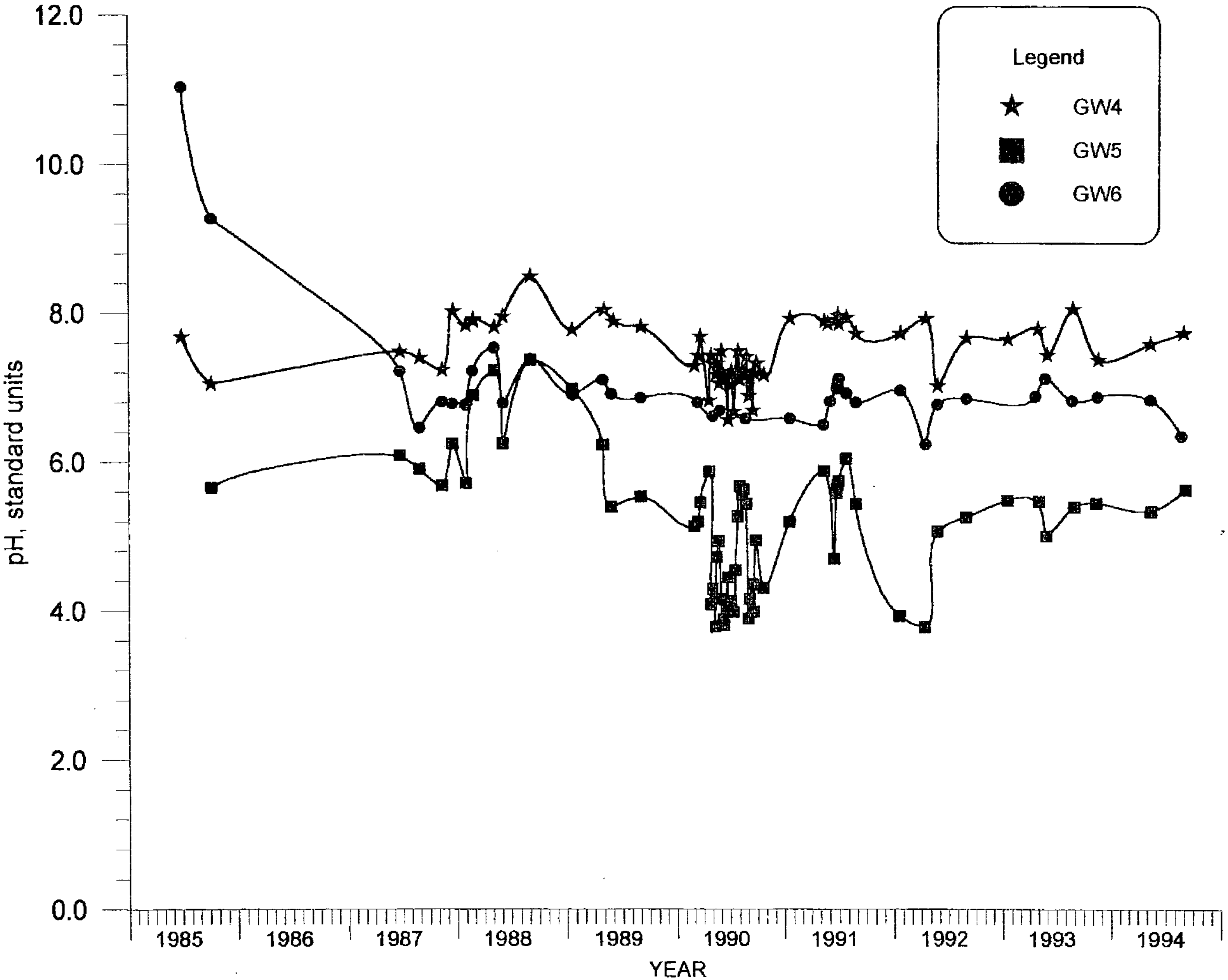

FIGURE 6-20. pH FOR WELLS GW4, GW5 AND GW6.

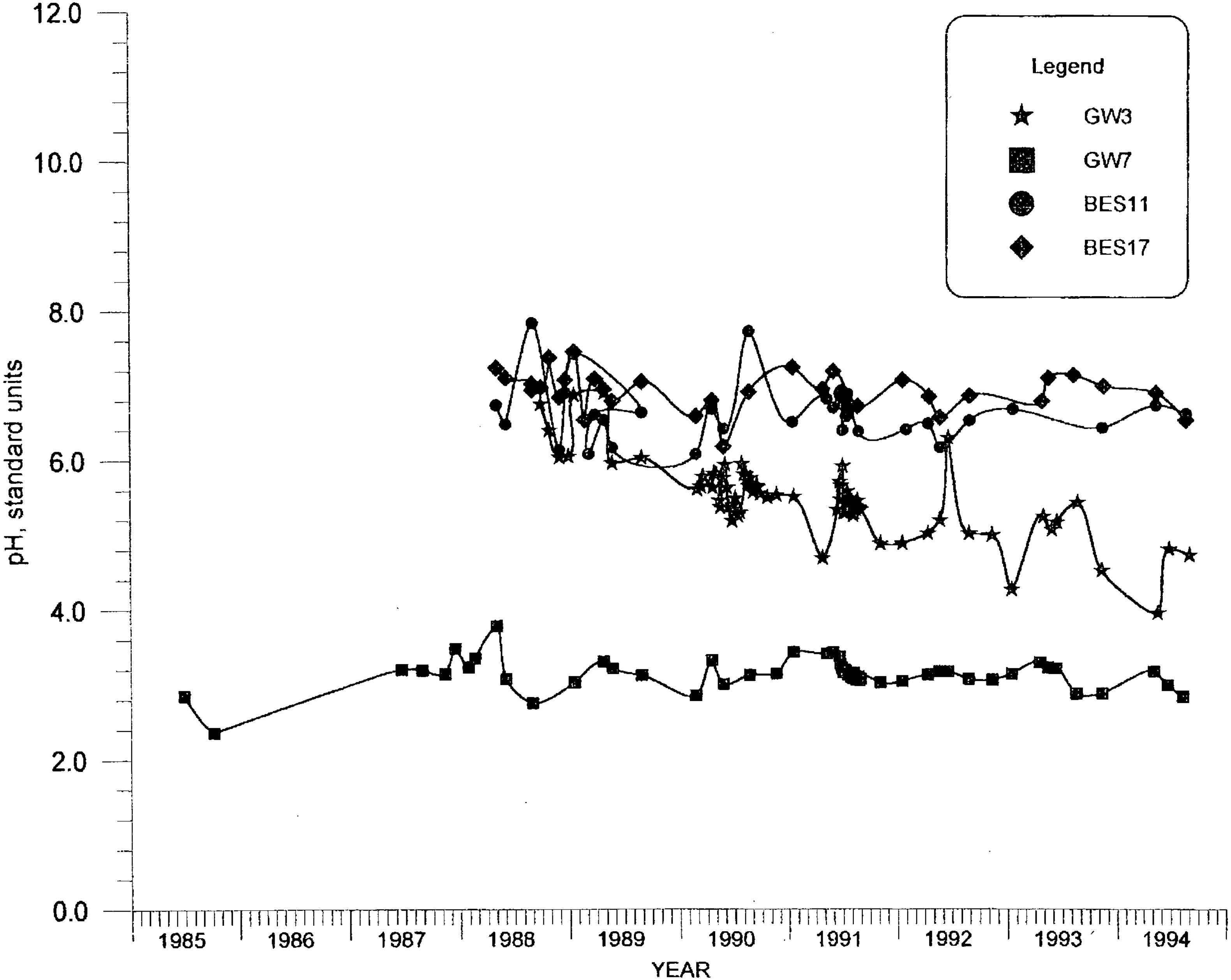

FIGURE 6-21. pH FOR WELLS GW3, GW7, BES11 AND BES17.

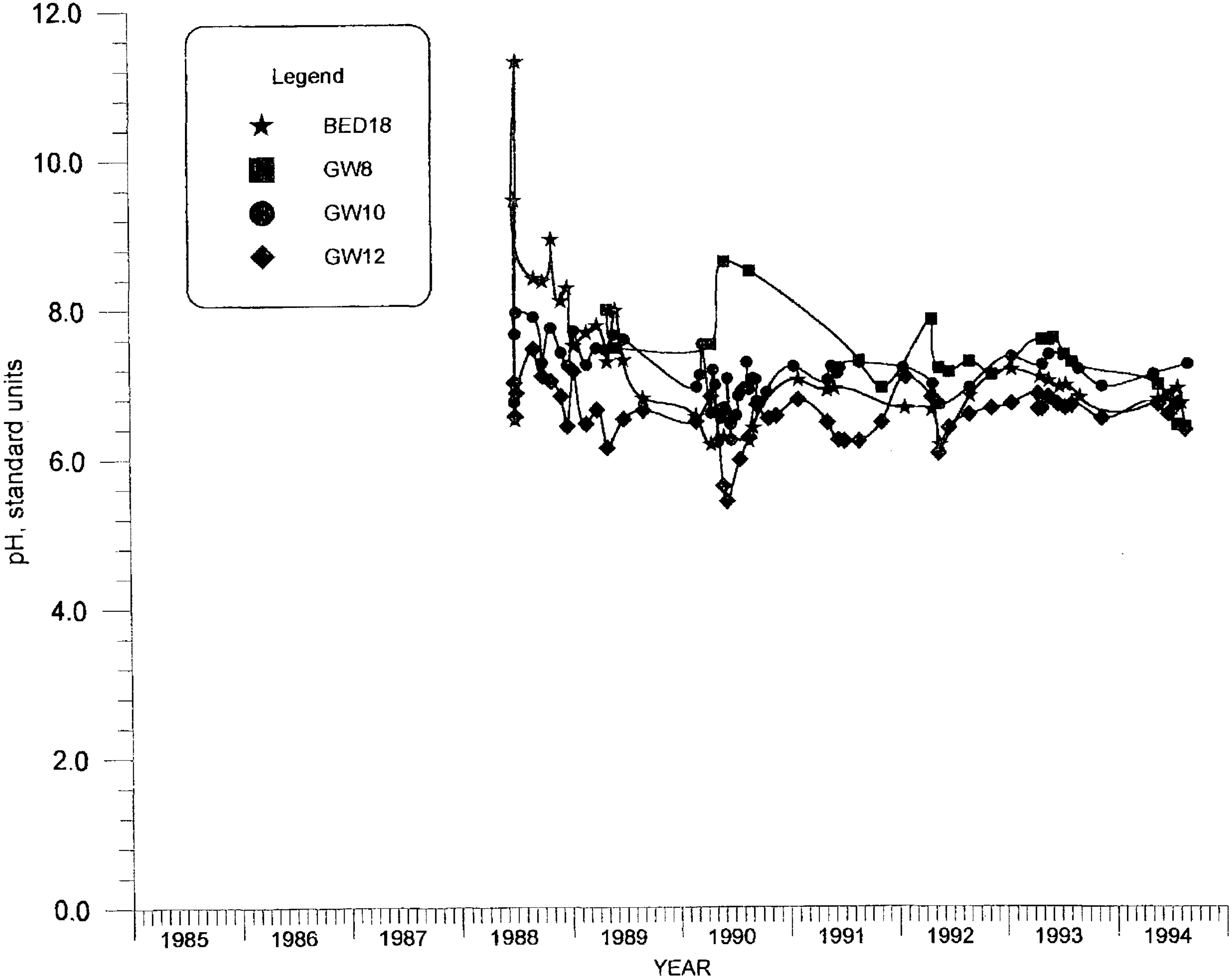

FIGURE 6-22. pH FOR WELLS BED18, GW8, GW10 AND GW12.

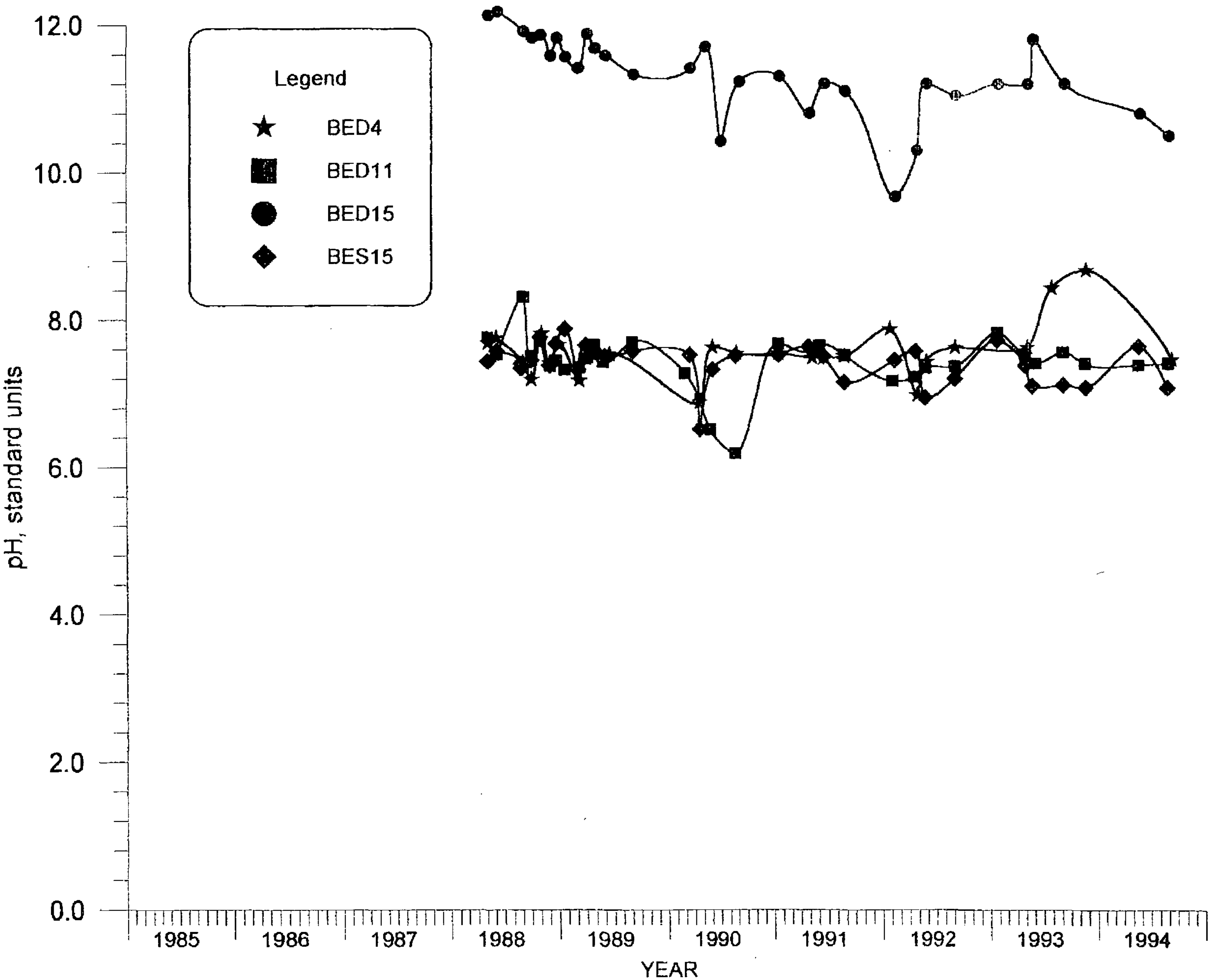

FIGURE 6-23. pH FOR WELLS BED4, BED11, BED15 AND BES15.